

## **Nature Conservation in Forest Management Plans for Small-scale Forestry in Sweden**

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This article examines how professional foresters choose areas set aside for nature conservation and studies how these compartments differ from production compartments in Green Forest Management Plans for small-scale forestry in Sweden. The implementation of the forest management plans is supposed to lead to the desired policy outcomes. However, there has been a concern from several stakeholders that economic considerations could weigh too heavily. Observations from about 5000 compartments have been analysed at the estate and compartment level using discriminant analysis and descriptive statistics. The discriminant analyses highlight that planners mainly use the data in the plan to propose goal classes. Most variables studied were within the desired ranges for the areas set aside for nature conservation, for example age, volume and percentage of broad-leaved trees. However, the compartments set aside for nature conservation were generally too small. In the south of Sweden the goal class 'Nature conservation goal with management' dominated, whereas the goal class 'Nature conservation goal based on no management' dominated in the north. Economic aspects were not found to be a major consideration when the planners selected compartments for nature conservation and the plans appear to comply with the new Swedish forest policy.

**Keywords:** nature conservation, forest policy, forest management plans

### **THE DEVELOPMENT OF GREEN FOREST MANAGEMENT PLANS**

During the 1980s, discussion about forestry as a major cause for the depletion of biological diversity intensified. The Bruntland report (World Commission on Environment and Development 1987) placed the issue on the international agenda. At the UN conference in Rio de Janeiro in 1992 (United Nations 1992), the final statement included ambitions towards a sustainable society in general and maintenance of biological diversity in particular. These discussions influenced attitudes of forest companies and the public in Sweden: most forest companies and forest owner associations started to investigate how to handle this issue and several

projects were initiated in which expertise on forest management and biological diversity was applied in an effort to combine the various goals (Rülcker *et al.* 1994, Dahlin and Sallnäs 1994).

Changing attitudes came to political manifestation as the new *Forestry Act* passed by the Swedish parliament came into force in 1994. The first paragraph of this Act (National Board of Forestry 1994, p. 8) stated: 'The forest is a National resource. It shall be managed in such a way as to provide a valuable yield and at the same time preserve biodiversity. Forest management shall also take into account other public interests'. At the same time, the regulations of the Act are less detailed than in its predecessor, leaving decisions largely to the forest owner. One example is the lowering of the minimum age required for final felling. In the previous Act, a forest management plan was required, whereas the *Forestry Act* of 1994 requires only a description of the forest.

With about 350,000 Swedish forest owners and an average estate size of about 50 ha, small-scale forest (sometimes referred to as non-industrial, smallholder or family forest (Harrison *et al.* 2002)) holdings encompass about 50% of the total forest area in Sweden (National Board of Forestry 2001a). In the south of Sweden, properties are smaller with a greater biological diversity compared to the north, mostly due to differences in climate. The small-scale forest owners are diverse as a group, with objectives covering a broad field from timber production to environmental conservation and amenities (Hugosson and Ingemarsson 2003).

Forest management plans in Sweden are mostly made by public agencies. Briefly, a plan is developed first by identifying and delineating compartments on a map with the help of aerial photographs and field control. Then for each compartment, averages for the following variables are estimated: site index, age, volume ( $\text{m}^3/\text{ha}$ ) and species composition. Additional variables may be estimated – e.g. diameter (breast height), height, stem density and wood quality – but they are not essential. The areas of compartments are then calculated. Finally, operations to be carried out during the following 10 years are proposed. Hence, the plan includes a description as well as a suggestion for management (National Board of Forestry 2001b).

When the new *Forestry Act* was passed, the National Board of Forestry began development work with green Forest Management Plans; simultaneously, other organisations were working with corresponding plans. The goal of a green forest management plan is to produce a comprehensive picture of production and environmental conditions of the property and to provide management proposals resulting in sustainable forestry. A commission to produce a plan provides an opportunity for implementing forest policy intentions in the management proposals. Contracted by the forest owner, the organisation produces the plan, and provides information and consultation. As a result of the development work with green forest management plans, a new variable describing a goal class for each compartment was added to the plan. In a green forest management plan, every compartment on productive forestland (forestland which can produce an average of at least  $1\text{m}^3/\text{ha}$  per year over the rotation period of the compartment) is assigned a goal class describing the direction of the long-term goals aimed at production or conservation. The goal classes express advice to the landowner on how the forest compartments should or could develop in the long term, and are supposed to be valid over several plan periods (one plan period is normally 10 years). Compartments with nature conservation goals are often given a more detailed description than compartments

with production goals. The four goal classes in use are (National Board of Forestry 2001b):

- PG - Production goal, with general environmental considerations
- PF - Production goal, with reinforced environmental considerations
- NS - Nature conservation goal, with management
- NO - Nature conservation goal, based on no management.

In compartments with nature conservation goal with management (NS):

environmental goals direct the nature conservation oriented management. The stand has high environmental values that require recurrent management activities to be preserved, or there are conditions present that allow the stand to return to similar high environmental values (National Board of Forestry 1999, p. 55.).

In compartments with nature conservation goal based on no management (NO):

the environmental goals are enhanced by free development. The stand has high environmental values that require it to be left untouched in order for it to be maintained or there are conditions present that allow the stand to return to similar high environmental values (National Board of Forestry 1999, p. 55.).

The management of NS may bring economic benefit, but that is not the main goal. The National Board of Forestry placed a minimum level of 5% per estate for the combined goal classes NS and NO, and in practice all organisations have adopted this limit. The level is a kind of political consensus, following the recommendations of FSC (Forest Stewardship Council) and PEFC (Pan-European Forest Certification).

The environmental goals of the national policy require nature conservation actions. These actions are addressed in the green forest management plans. The implementation of the forest management plans is supposed to lead to the desired result of the policy. However, there has been a concern from several stakeholders that economic consideration could weigh too heavily. The green management plan highlights the nature values of the property, leading to improved possibilities for selling the timber. Even if the area goal of 5% is fulfilled, the compartments for nature conservation may not be chosen primarily to maintain the biodiversity but rather to minimise the economic loss of the set-asides.

The aim of this article is to examine how professional foresters choose areas set aside for nature conservation and to study how these compartments differ from production compartments in green forest management plans for small-scale forestry in Sweden. If implementation of the policy results in the desired effect then conservation aspects must have been more decisive than economic aspects when choosing the compartments to be set aside for nature conservation. This study did not examine the economic value of the different compartments and the natural values of the compartments were not studied in the field. It concentrated on some important variables which can be found in a green management plan, including age, area, percent of broad-leaved trees, percent of spruce, region, site index and volume.

## RESEARCH METHOD

Ninety forest management plans were sampled from five planning organisations in Sweden. The policy documents and inventory instructions for the organisations were compiled and the contents were analysed, with emphasis on nature conservation. To provide information on the policy for consulting with the forest owner, two planners from each organisation were interviewed in order to study the counselling concept to the forest owner. Furthermore, the person responsible for the green forest management plans within each organisation were interviewed. Planners were asked to describe the scheme for planning and counselling. At the end of each interview, the researcher verified his understanding of the informant's statements and asked for amendments, following the method used by Kvale (1996). The interviews lasted on average for two hours and were tape-recorded, typed and analysed. Data reduction was used in focusing, sharpening and organising the data, and was conducted in accordance with the method used by Miles and Huberman (1994). Empirical examples were chosen to highlight the experiences of the professional foresters.

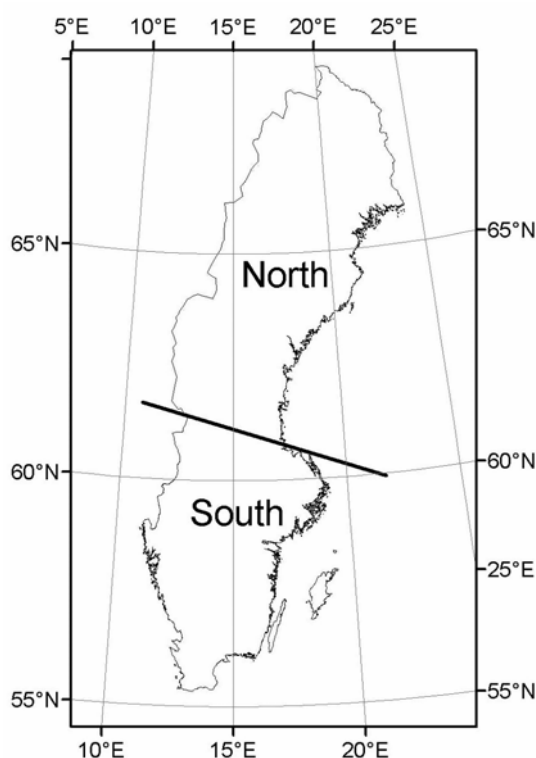
### **Spatial Distribution of the Sample of Forest Management Plans**

The five planning organisations were selected on the basis that they were the largest plan producers, they had been producing green forest management plans since 1998 and they covered 80% of the total area of management planning in Sweden in year 2000. The organisations were:

- The Forestry Board Organisation, the common name for the National Forestry Board and the Provincial Forestry Boards. This is a governmental organisation with the main objective of providing correct and sound environmental management of forests according to the directives of the government and parliament. The Forestry Board Organisation produced plans for 227,000 ha in year 2000 and contributed 20 plans to the study.
- Södra, a forest owner association with almost 34,000 members in the south of Sweden, which owns 2 M ha of forest. Södra planned 200,000 ha during year 2000 and contributed 20 plans to the study.
- Mellanskog, a forest owner association working in central Sweden, which has more than 22,000 members owning 1.5 M ha of forest. They planned 80,000 ha during year 2000 and contributed 10 plans to the study.
- Sydved AB, owned two-thirds by StoraEnso and one-third by Munksjö, works largely with small-scale forest owners supplying pulpwood to the owners' industries in the south of Sweden. Sydved planned 35,000 ha in year 2000 and contributed 20 plans to the study.
- Skogssällskapet, an independent foundation, which manages forest for private forest owners, municipalities and foundations. Skogssällskapet manages 450,000 ha of forest for more than 1,000 owners. The foundation planned about 30,000 ha during the year 2000 and contributed 20 plans to the study.

The sample included estates from throughout Sweden; however, because small-scale forest owners are more prevalent in the south a greater number of plans was drawn from this area. In total, the area covered was 12,500 ha, corresponding to 2% of the area planned in Sweden in year 2000. The estates varied in size between 11 ha and

660 ha. Of the 5223 compartments, 10% had goal classes NS or NO and the average size of each compartment was 2.4 ha. The sample was further divided into two groups to determine differences between the north and south of the country. Forestry in North Sweden is dominated by forest companies and small scale forestry has less significance. Consequently, a smaller number of plans were chosen from the north of Sweden; out of the 90 plans 19 came from the north, representing 42% of the area. The river Dalälven (Limes Norrlandicus), about 150 km north of Stockholm, was used as the border between the two groups (Figure 1).



**Figure 1.** Map of Sweden with the north-south delimitation indicated

Goal classes PG and PF were considered as one class in the analyses, whereas NS and NO were differentiated because the criteria for defining them differs. The productive forest area is divided into 20 year age intervals.

#### **Discriminant Analysis and Statistical Methods**

Discriminant analysis was adopted because a facility was needed for classifying observations, and the groups of goal classes were known *a priori*. Initial interest centred on variables as possibilities for distinguishing between classes. A question was whether some subsets of the original variables could provide a classification rule equal in performance to the rule based on using all available variables. A discriminant analysis procedure (Discrim) in the SAS statistical package (SAS Institute Inc. 1999) was used for the statistical tests.

Stepwise discriminant analysis was used to identify significant variables for discriminating goal classes. The model used a measure of ‘separability’ of groups and began with all available variables, and sequentially eliminated those for which the removal led to the least reduction in separation. Seven variables were analysed from the sample, namely percentage of broadleaf species of the basal area, age, site index, volume per hectare, location in the south or the north of Sweden, area, and the percentage of spruce of the basal area. The three class levels were Nature conservation goal with management (NS), Nature conservation goal based on no management (NO) and Production goal (PG and PF). The significance level to enter or stay was 0.15.

The assumption of equal covariance matrices was used, even if this was not completely fulfilled. A linear discriminant function was considered appropriate for examining how professional foresters chose areas set aside for nature conservation.<sup>1</sup> The discriminant function is determined by a measure of generalised squared distance (Rao 1973). An observation is classified into a group if the squared distance of observation to the group centre is the minimum. There is a unique part of the squared distance formula for each group and this is called the linear discriminant function for that group. The coefficient vector and constant used by the linear discriminant function is shown below, where  $\bar{X}_j$  is the vector of mean values for group j:

$$\text{Coefficient Vector} = \text{COV}^{-1} \bar{X}_j$$

$$\text{Constant} = -0.5 \bar{X}_j' \text{COV}^{-1} \bar{X}_j$$

The performance of the linear discriminant function was evaluated by estimating error rates (probabilities of misclassification) in the classification of future observations. The different goal classes had equal probabilities. The observed probabilities would have resulted in a better solution for the whole dataset but with increased misclassification for the smaller classes NO and NS. The data of 5233 compartments was divided into two datasets. The derived linear discriminant function from the first subset was applied to a second subset, a calibration set, and the hence misclassification figures derived. Additional analyses of variances were performed for variables of special interest. A significance test was made firstly, on the differences in average compartment area, for compartment with nature conservation and production goals and secondly, on the differences in average forest area per management plan, reserved for the goal classes NS and NO in southern and northern Sweden.

An attempt was made to define desired effects, from an nature conservation point of view, prior to the stepwise discriminant analysis (Table 1). The production goal was seen as the default class. NS and NO were given the desired effects – low, intermediate, high, south or north. For example, high natural values are often found in older forests with some gaps and dead wood. A high percentage of spruce often

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<sup>1</sup> If the covariance of the two groups had differed, the discrimination rule would have been more complex, and a quadratic discriminant function would have been used. This was also tested but did not radically change the result and did not produce any better solution.

creates monocultures, but also dead wood. Broad-leaved forests frequently have high natural values and need to be managed to preserve that state. In the southern part of the country, the site index was generally higher, indicating management is needed to preserve that state.

**Table 1.** The desired effects for an analysis of the significant variables according to the stepwise discriminant analysis

Variable	NO	NS
Broad-leaved trees (%)	Low	High
Age (years)	High	High
Site index (height in m at 100 yrs)	Low	High
Volume (m <sup>3</sup> /ha)	Intermediate	Intermediate
Area (ha)	High	High
Spruce (%)	Intermediate	Low
South/North	North	South

## RESULTS

The results section firstly presents the policy, instructions and consultations connected to the production of a green forest management plan. Thereafter, the other sections present the results for the areas set aside for nature conservation on estate and compartment level.

### Policy, Instructions and Consultations

The national forest policy objectives, accepted by the Swedish Parliament, have been made into concrete objectives by the National Board of Forestry in consultation with the forestry sector. The current situation and the objective for year 2003 were described under each sector objective. All organisations describe their policy and forestry intention with reference to environmental and production goals: these goals should have equal status according to the first paragraph in the *Forestry Act*. The National Board of Forestry has presented the clearest and most detailed policy, containing intermediate goals for both internal and external use, and including a description of the goal of the green forest management plans.

The instruction for producing a green forest management plan should be operative and follow the policy to become efficient. Concerning the disposition and formulations in the instructions, it appears that all organisations have incorporated the instruction of the National Board of Forestry. For all organisations, the definitions of goal classes follow the National Board of Forestry's instruction. The description of nature values consists of a description of the occurrence of nature values, which refers to species, structures and topography important for sustainable forest management, and contains at least one description of nature values for nature conservation compartments. However, the descriptions display great differences in degree of detail between different planners. The organisations in the study had the possibility of producing a modified plan for certification by FSC or PEFC, and in

compliance with this instruction, all organisations counted NS and NO as areas set aside for environmental reasons.

Consultations, acting as a link between the policy, the instruction, the forest management plan and the landowner, took place on several occasions: before and during the fieldwork, during the briefing of the preliminary plan and at delivery of the final plan. The time demands of the planning placed high pressure on the inventory staff. They often did not have the opportunity or time to present the management plan to the forest owners, especially those with small forest areas. As exemplified by one professional forester: ‘Many forest owners do not live on their property and I can seldom bring the forest owner to the forest during the inventory, because time is short if the price per hectare (cost of developing plans) should be low.’ As a result, the forest owner did not always participate in the process of deciding goal classes.

Different planners had different methods for consulting; these differences were on an individual level rather than on an organisational level. For example, one forest planner said: ‘It is seldom that the goal classes are discussed as long as they do not exceed 5% (of the area of the estate) by too much.’ while another forester said ‘I always discuss the goal classes with the forest owners.’ Sometimes there is a conflict between economic and nature values, as exemplified by an empirical example: ‘generally, few conflicts between economic and nature values arise ... they appear in areas where the forest owner cannot see the nature value of, for example, a coniferous forest with one third of aspen.’

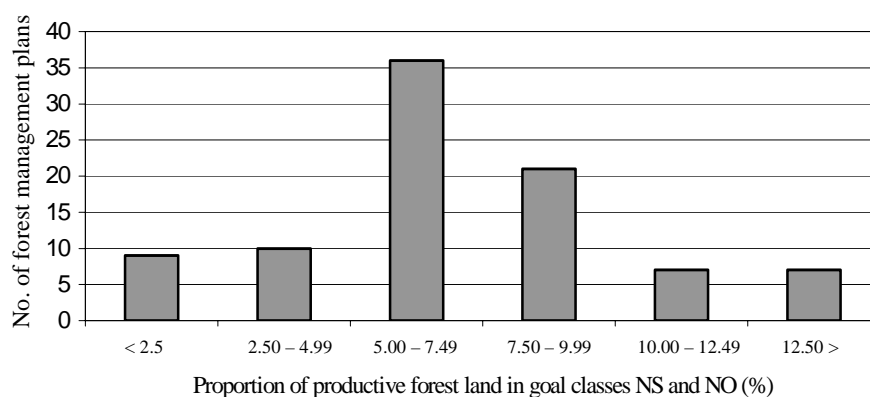
#### **Nature Conservation on Estate Level**

The goal classes NS and NO covered approximately 6.7% of the total productive forest area, corresponding to 7.0% of the standing volume in the plans studied, as reported in Table 2.

**Table 2.** Forest area and standing volume distribution over the various goal classes

Goal class	P	NS	NO
Proportion of forest area (%)	93.3	2.4	4.3
Proportion of standing volume (%)	93.0	2.9	4.1

A majority of the plans had at least 5% of the productive forest area reserved for goal classes NS and NO (Figure 2). Nineteen of the plans (21%) classified less than 5% of the area to goal classes NS and NO, and 5 plans had no areas reserved for these goal classes.



**Figure 2.** Proportion of forest area in goal classes NS and NO per estate

### Nature Conservation on Compartment Level

A regression analysis tested whether the choice of nature conservation areas depends on the estate to which it belongs. No correlation was detected and thereafter all 5223 compartments were analysed irrespective of the estate to which they belonged. Small differences were found between the different agencies producing the plans. Although one organisation had a considerably higher number of plans with a very low percentage set aside, the variation within the organisations was larger than between them. The data collected did not allow statistical analyses on an individual planner level, because the planner was not recorded for every plan.

The stepwise discriminant analysis showed that seven variables have a significant effect, resulting in the classification of NO, NS and P (Table 3). Some variables in the forest management plan are strongly correlated, for example basal area and volume. Either one of them could have been used. In most cases, one of the correlated variables was assessed during the field inventory and the other one was calculated from that value in the office.

**Table 3.** The importance of different variables for choosing goal classes according to the stepwise discriminant analysis

Variable	Partial R-square	F Value	Significance level
Broad-leaved trees (%)	0.1221	360.86	< 0.0001
Age (years)	0.1014	292.83	< 0.0001
Site Index (m at 100 yr)	0.0401	108.38	< 0.0001
Volume (m <sup>3</sup> /ha)	0.0108	28.24	< 0.0001
South/North	0.0093	24.23	< 0.0001
Area (ha)	0.0066	17.21	< 0.0001
Spruce (%)	0.0024	6.36	0.0017

Table 4 defines the discriminant function with the coefficients used to evaluate the probabilities of misclassification in the classification of future goal classes.

**Table 4.** Estimated linear discriminant function for each goal class

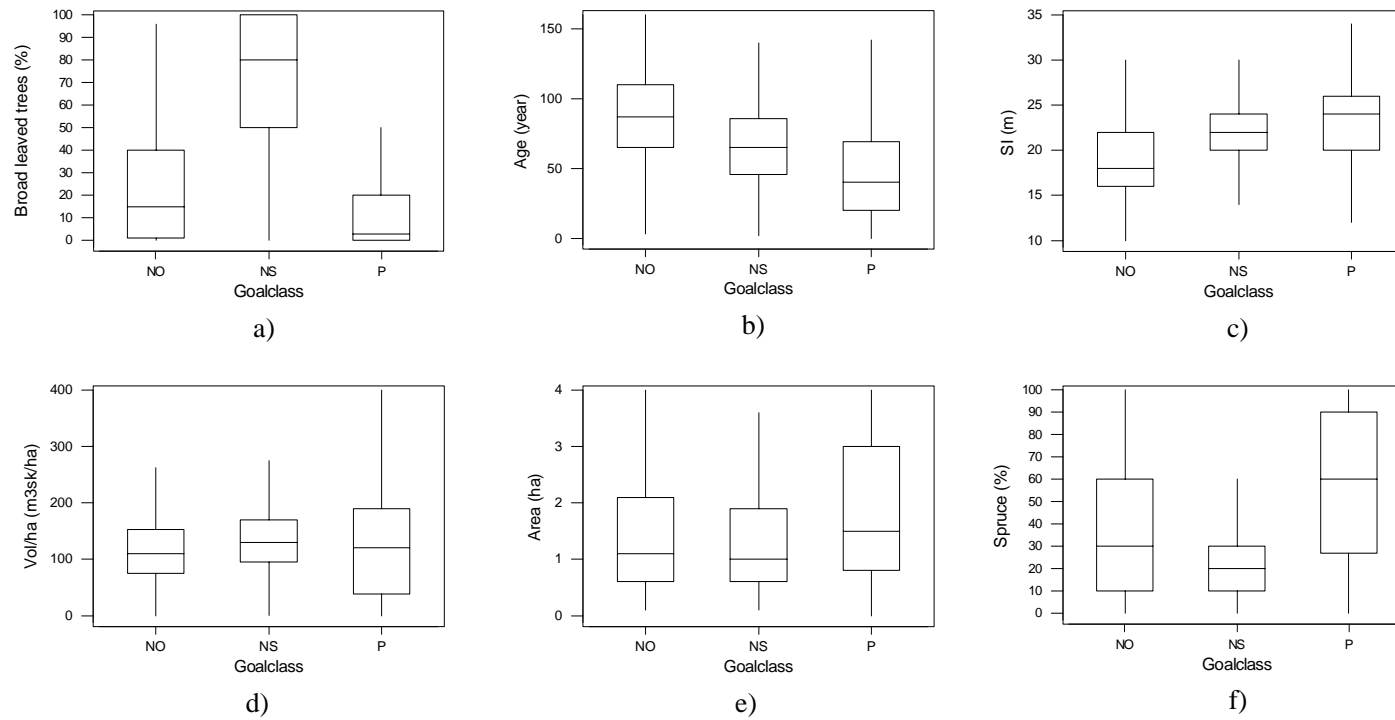
Variable	NO	NS	P
Constant	-50.50	-57.40	-54.16
Area (ha)	0.33	0.40	0.45
Age (yr)	0.25	0.23	0.20
Volume (m <sup>3</sup> /ha)	-0.05	-0.05	-0.05
South/North	18.15	18.3	19.15
Broad-leaved trees (%)	0.10	0.15	0.08
Spruce (%)	-0.07	-0.08	-0.08
Site Index (m at 100 yr)	3.16	3.40	3.40

Table 5 reports the differences between the classification according to the linear discriminant model and the classification according to the professional foresters. According to the model the forester misclassified 22% of NS into NO, and 20% of NO was misclassified into NS. Fourteen percent of P was misclassified into NO and 11% of P was misclassified into NS. According to the model 12% of NO and 8% of NS were misclassified into P by the foresters.

**Table 5.** Forest stands classified into goal classes NO, NS and P, according to the linear discriminant function

True goal class	Goal class classification by linear discriminant analysis			
	NO (%)	NS (%)	P (%)	Total (%)
NO	68.32	19.80	11.88	100.00
NS	22.0	70.00	8.00	100.00
P	14.26	10.76	74.98	100.00
Total	17.95	13.21	68.84	100.00

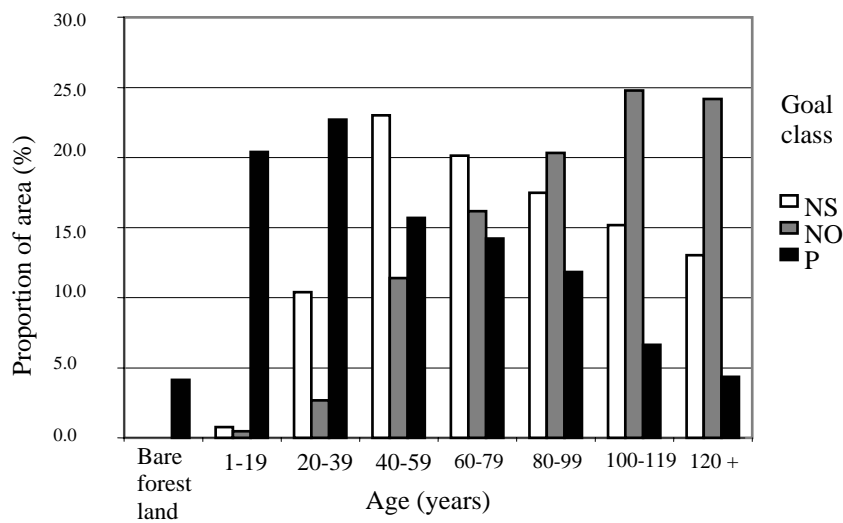
Figure 3 shows the distribution of six of the seven significant variables. It is clear in Figure 3 (a) that the goal class NS has a considerably higher proportion of broad-leaved trees than the other goal classes and that the median compartment in goal class P contains less than 10% broad-leaved trees. In Figure 3 (b) goal class NO has the highest median value and P has the lowest value. This is also illustrated in Figure 4, which shows the proportion of total areas for the various goal and age classes. NO has a large proportion of the area in older age classes. This trend was not as strong in NS compartments. In goal class P, a high proportion of the compartments were young age classes.



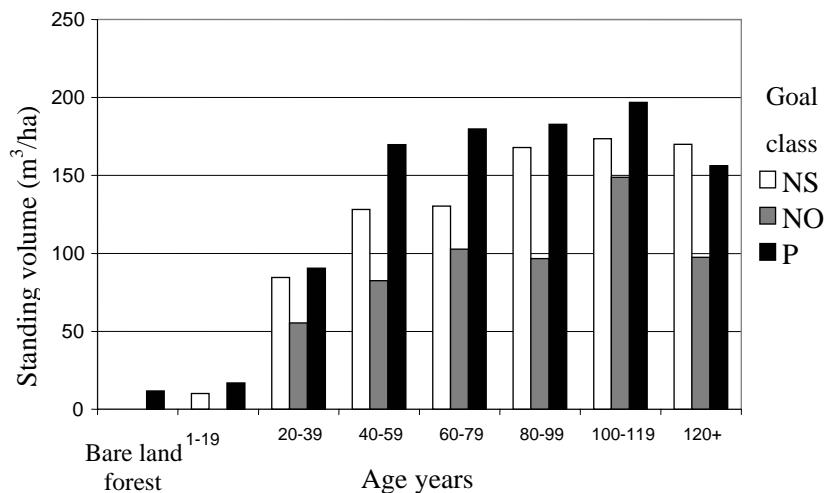
**Figure 3.** Box-whisker plots of the six variables divided on the goal classes

Note: In a box-whisker plot, the box indicates the first quartile, median and third quartile, while the whiskers indicate the range.

Figure 3 (c) indicates that the site index for goal class P has the highest median and NO the lowest. The volume per hectare has high variation (Figure 3 (d)). The lower quartile shows that production compartments have a high proportion of young stands compared to the other goal classes. Figure 5 provides a better understanding of the sample. For compartments aimed primarily at forest production, the average volume ( $\text{m}^3/\text{ha}$ ) increases with increasing age up to the age class 100-119 years. The age class 120+ years is above the normal rotation age: compartments in this age class had not been treated according to normal silvicultural practice or had a low site index. The same trend is seen for compartments for nature conservation with management (NS); however, the trend is not clear regarding compartments that were supposed to be left untouched (NO).



**Figure 4.** Proportion of total area for each goal and age class



**Figure 5.** Proportion of average standing volume for each goal and age class

Figure 3 (e) shows the area of compartments for the various goal classes. The difference is smaller between the medians than between the mean values of the goal classes. As indicated here and in Table 6, the average compartment area is smaller for goal classes with nature conservation than for production compartments. Figure 3 (f) shows the percentage for spruce in each goal classes. The value for the median is much higher for P than for the nature conservation classes, and especially NS.

**Table 6.** Average areas of compartments with nature conservation and production goals

Goal class	No. of compartments	Average compartment area (ha) <sup>a</sup>	Std dev.	Min	Max
NS/NO	520	1.49	1.82	0.1	13.8
P	4703	2.47	3.26	0.1	53.9

a. The mean area for goal class P exceeds that for goal classes NS and NO at the 0.1% significance level.

The dummy variable south/north cannot be depicted in a box plot. For the total proportion set aside in goal classes NS and NO, there is little difference between the parts of the country. However, there is a significant difference between these two goal classes; the proportion reserved for goal class NS is higher in the south and goal class NO dominates in the north (Table 7).

**Table 7.** Average forest area per management plan, reserved for the goal classes NS and NO in southern and northern Sweden

Goal class	NS (% of area) <sup>a</sup>	NO (% of the area) <sup>b</sup>
Southern Sweden	4.22	3.23
Northern Sweden	0.89	5.23

a. Difference significant at the 0.1% level.

b. Difference significant at the 1% level.

## DISCUSSION

The discussion is divided, in the same way as the result section, firstly with the heading policy, instructions and consultations. Thereafter the other sections of the results are discussed with the areas set aside for nature conservation on estate and compartment level.

### Policy, Instructions and Consultations

The policy and inventory instructions of the organisations participating in the survey correspond to the National Forestry Boards policy and instructions. All organisations provided education in nature conservation for the professional foresters. However, personal differences occur in the way the forester interprets the instructions for the goal classes.

The organisations clearly describe their policies regarding nature conservation and production goals. The National Board of Forestry produces the clearest and most detailed policy of the organisations studied. All policy documents in the study highlighted the environmental awareness of the organisations in a clear way for both the forest owner and the public. All instructions had similar dispositions and formulations and the goal classifications broadly follow the instruction of the National Board of Forestry.

Contact between the forest inventory staff and the forest owner is a weak point, and differs little between the organisations studied. The differences are greater on an individual level than on an organisational level. The description of nature values, which the organisations have for the compartments with goal classes for nature conservation, is a good foundation for discussions with landowners, and together they could assess the priorities for areas set aside for nature conservation according to the objectives of the forest owner.

### **Nature Conservation on Estate Level**

The percentage of the area reserved for nature conservation corresponds to the percentage of the timber volume reserved; hence, these areas do not seem to be chosen because of low volume. A majority of the plans fulfilled the recommendation stated by the National Board of Forestry, that at least 5% of the productive forest area should be reserved for goal classes NS and NO. However, the recommendation that at least 5% of the productive forest area should be set aside for nature conservation was not always fulfilled. One reason is that existing areas suitable for nature conservation are not always present when the plans are prepared and the possibility for creating such areas was not considered. Another reason is probably that one of the planning organisations in their instructions to the planners only recommended 5% of the property area to be set aside for nature conservation.

### **Nature Conservation on Compartment Level**

The box plots in Figure 3 reveals that goal class NS has a considerably higher proportion of broad-leaved trees than the other goal classes. This was a desired effect from the choice of nature conservation areas. However, the median compartment in goal class P contains less than 10% of broad-leaved trees, which is the recommended minimum stated by the National Board of Forestry. A reason for the high proportion of broad-leaved trees in goal class NS might be that this goal class is predominant in southern Sweden where most of the forest land is culturally influenced with a high proportion of grazing land and marshes with alder trees. Furthermore, the reason for the low proportion of broad-leaved trees in goal class P might be that up to about 1980 broad-leaved trees were considered less valuable and hence were removed in pre-commercial thinning or first thinning.

NS and NO generally have a higher age than compartments with a production goal. This could be due to compartments with older trees being more suited to nature conservation, whereas young forests are primarily established for production purposes, as a result of which most of the young forest areas become production compartments. This effect is desirable for nature conservation. The median of the age variable for the NS compartments is lower than that for NO compartments. One reason could be the high proportion of broad-leaved trees including birch and aspen in NS, resulting in a shorter rotation period.

Compartments in the goal class NO are generally older and have a lower site index than the other goal classes. Compartments with a production goal are generally younger and have a higher site index than compartments for nature conservation. The high proportion of birch and aspen within the NS compartments could be one reason for the lower quartile shown in plot C (Figure 3). The low site index for NO and the high median for NS are desirable effects for the choice of nature conservation areas. Compartments on better sites need frequent maintenance, whereas compartments on poorer sites, mostly conifers, are often left unmanaged in order to create as near to a virgin forest as possible. Goal class NO is more frequent in the northern part of Sweden where it is more common to set aside compartments for nature conservation and free development without any management. This is often the case in old stands situated on land with low site index where the forest has a longer rotation period. That the proportion reserved for goal class NS is higher in the south and goal class NO dominated the north is a desired effect.

The compartments with production goals have a higher proportion of spruce compared to the other goal classes. The median reflects the situation for the whole of Sweden. Generally, forest compartments with the highest production potential have been set aside for forest production. In Swedish conditions, spruce is the most profitable species on highly productive sites. One reason for the low proportion of spruce in goal class NO is that Sweden has two indigenous conifers, Norwegian Spruce and Scots Pine. Pine is less productive on fertile soils but is dominant on poor soils. Furthermore, the expected lifetime of pine is much longer than spruce and the wood is more durable. The low percentage of spruce in the NS compartments (Figure 3c) and the intermediate level of spruce in NO compartments are consistent with the desired effects.

The standing volume in cubic metres per hectare varied between goal classes. One reason is that all age classes, from bare forestland to mature forests, should be represented in a management plan in order to facilitate forestry activities on a sustainable level. The result for the standing volume per hectare for the different goal classes follows the desired effect for nature conservation. The average area of the compartments in goal classes NS and NO is smaller than compartments in the goal class P. This is undesirable for choosing nature conservation areas. One reason for this could be that compartments with production goals need to be of sufficient size and suitable shape for rational management. Another reason might be that areas of interest for nature conservation are often small and were earlier included in production compartments. Some of the compartments set aside for nature conservation are less attractive for harvesting, because of their location and species composition. These areas are often small, but could still have a high volume and site index. Examples of such compartments are stands situated along streams, stands connected to lakes, and swamp areas within the forest. Such types of stands are also less attractive for harvesting, both for environmental and economic reasons.

The average volume per hectare increased with increasing age for all goal classes; however, this trend was not clear for compartments in class NO, possibly due to compartments being situated on poor sites with low standing volumes throughout the rotation period. Many of the compartments in the goal class NO were also considered to be virgin forests with a balance between production of new and dead wood. The total share of area, as well as volume, for classes NS and NO are approximately the same in both southern and northern Sweden, with class NS more

dominant in the south and class NO dominant in the north. NS is more frequent in southern Sweden due to better growing conditions. This is in line with regional classifications (e.g. Ahti *et al.* 1968, Sporrang *et al.* 1995) and recommendations from National Board of Forestry (2001a).

The forest management plan should take the objective of the forest owner into consideration and likewise the plan should give the forest owner the opportunity to take the views of the society into consideration. Therefore, the suggestions of goal classes in the forest management plans are not only dependent on the variables within the plan. Other criteria are involved in decision making by the professional forester, such as the occurrence of endangered species. The areas set aside for nature conservation are recommendations and it is not possible to predict the degree to which these will be followed by the small-scale forest owners.

Three important factors are highlighted by the linear discriminant function. The greatest problem for the analysis was to determine the difference between NS and NO. In many cases it was not evident whether there should be management or not on the area set aside for nature conservation. Some of the production compartments were misclassified into nature conservation compartments. One reason for this might be that there are more compartments suitable for nature conservation than the forest owner wished to set aside. A few nature conservation compartments seem to be misclassified into production. In these cases there could be a lack of suitable compartments for nature conservation.

The statistical treatment of the data was conducted using multivariate data analysis. The authors decided to use discriminant analyses, because three classes needed to be discriminated. Logistic regression analysis is suitable to use for any number of classes, but is mostly used for two classes. Although it may be possible to use logistic regression, it is unclear if this technique is a better choice because discriminant analysis was developed for this type of problem. The green management plans have only been on the market for a few years over the whole of Sweden, thus the results of the linear discriminant analysis could be used for future classification of compartments into classes. It would be interesting to evaluate how the professional foresters will make the classification in the future when they have gained more experience.

## CONCLUSIONS

The model was able to discriminate between nature conservation compartments and production compartments. According to the model about 70% of the proposed goal classes, according to the professional foresters, are classified into the correct classes. This indicates that planners mainly use the data in the plan to propose goal classes. There has been a discussion about whether economic considerations affect how nature considerations are set aside. Most of the variables studied showed the desired numbers for the areas set aside for nature conservation, for example age, volume and percentage broad-leaved trees. However, the compartments set aside for nature conservation were generally too small. In the south of Sweden goal class NS dominates, whereas goal class NO dominates in the North. Economic consideration were not found to be the major consideration by the planners for the selection of NS

and NO. However, to be certain that selection of compartments is ecologically correct, further studies, including field tests, are necessary.

The planning organisations studied have adopted the recommendations submitted from the National Board of Forestry. There are clear indications that green forest management plans have complied with the changes in the new national forest policy in Sweden. The national policy seems to be successful. Because the green forest management plans were only recently produced it is too early to analyse the extent to which small-scale forest owners have followed the guidelines laid out in the plans.

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